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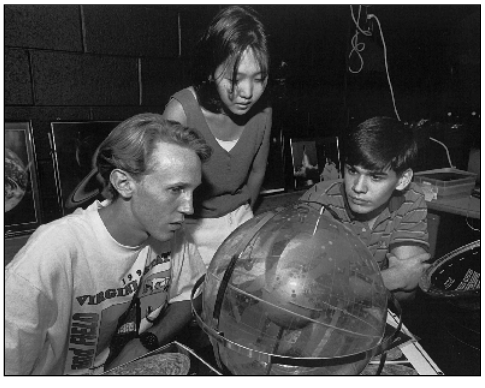
Introduction



The *National Science Education Standards* are designed to guide our nation toward a scientifically literate society. Founded in exemplary practice and research, the *Standards* describe a vision of the scientifically literate person and present criteria for science education that will allow that vision to become reality. ▮ Why is science literacy important? First, an understanding of science offers personal fulfillment and excitement—benefits that should be shared by everyone. Second, Americans are confronted increasingly with questions in their lives that require scientific information and scientific ways of thinking for informed decision making. And the collective judgment of our people will determine how we manage shared resources—such as air, water, and national forests.

Science understanding and ability also will enhance the capability of all students to hold meaningful and productive jobs in the future. The business community needs entry-level workers with the ability to learn, reason, think creatively, make decisions, and solve problems. In addition, concerns regarding economic competitiveness stress the central importance of science and mathematics education that will allow us to keep pace with our global competitors.

Why National Science Education Standards?

The term "standard" has multiple meanings. Science education standards are criteria to judge quality: the quality of what students know and are able to do; the quality of the science programs that provide the opportunity for students to learn science; the quality of science teaching; the quality of the system that supports science teachers and programs; and the quality of assessment practices and policies. Science education standards provide criteria to judge progress toward a national vision of learning and teaching science in a system that promotes excellence, providing a banner around which reformers can rally.

A hallmark of American education is local control, where boards of education and teachers make decisions about what students will learn. National standards present criteria by which judgments can be made by state and local school personnel and communities, helping them to decide which curriculum, staff development activity, or assessment program is appropriate. National standards encourage policies that will bring coordination, consistency, and coherence to the improvement of science education: They allow everyone to move in the same direction, with the assurance that the risks they take in the name of improving science education will be supported by policies and practices throughout the system.

Some outstanding things happen in science classrooms today, even without national standards. But they happen because extraordinary teachers do what needs to be done despite conventional practice. Many generous teachers spend their own money on science supplies, knowing that students learn best by investigation. These teachers ignore the vocabulary-dense textbooks and encourage student inquiry. They also make their science courses relevant to students' lives, instead of simply being preparation for another school science course.

Implementation of the *National Science Education Standards* will highlight and promote the best practices of those extraordinary teachers and give them the recognition and support they deserve. School principals who find money in their budgets for field trips, parents whose bake-sale proceeds purchase science equipment, and publishers who are pioneering authentic assessments despite the market for multiple-choice tests will also be recognized and encouraged.

The *Standards* help to chart the course into the future. By building on the best of current practice, they aim to take us beyond the constraints of present structures of schooling toward a shared vision of excellence.

Goals for School Science

The goals for school science that underlie the *National Science Education Standards* are to educate students who are able to

- experience the richness and excitement of knowing about and understanding the natural world;
- use appropriate scientific processes and principles in making personal decisions;
- engage intelligently in public discourse and debate about matters of scientific and technological concern; and
- increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.

These goals define a scientifically literate society. The standards for content define what the scientifically literate person should know, understand, and be able to do after 13 years of school science. The separate standards for assessment, teaching, program, and system describe the conditions necessary to achieve the goal of scientific literacy for all students that is described in the content standards.

Schools that implement the *Standards* will have students learning science by actively engaging in inquiries that are interesting and important to them. Students thereby will establish a knowledge base for understanding science. In these schools, teachers will be empowered to make decisions about what students learn,how they learn it, and how resources are allocated. Teachers and students together will be members of a community focused on learning science while being nurtured by a supportive education system.

Students could not achieve the standards in most of today's schools. Implementation of the *Standards* will require a sustained, long-term commitment to change.

History of the *National Science Education Standards*

Setting national goals and developing national standards to meet them are recent strategies in our education reform policy. Support for national education standards by state governments originated in 1989, when the National Governors Association endorsed national education goals. President George Bush immediately added his support by forming the National Education Goals Panel. The support for standards was continued by the new administration after the election of President William Clinton.

The first standards appeared in 1989, when mathematics educators and mathematicians addressed the subject of national standards with two publications: *Curriculum and Evaluation Standards for School Mathematics*, by the National Council of Teachers of Mathematics (NCTM) (1989); and *Everybody Counts: A Report to the Nation on the Future of Mathematics Education*, by the National Research Council (1989). The NCTM experience was important in the development of other education

standards,and it demonstrated that participation in the development of standards had to be open to all interested parties, especially those responsible for their realization.

The *National Science Education Standards* had several important precursors. In 1983, *A Nation at Risk* was published,calling for reconsideration and reform of the U.S. education system. In the 1980s,the American Chemical Society (ACS), the Biological Sciences Curriculum Study, the Education Development Center, the Lawrence Hall of Science,the National Science Resources Center (NSRC),and the Technical Education Resources Center all developed innovative science curricula. In 1989, the American Association for the Advancement of Science (AAAS), through its Project 2061, published *Science for All Americans,* defining scientific literacy for all high school graduates. Somewhat later, the National Science Teachers Association (NSTA),through its Scope, Sequence & Coordination Project, published *The Content Core*.

In the spring of 1991, the NSTA president, reflecting a unanimous vote of the NSTA board, wrote to Dr. Frank Press—president of the National Academy of Sciences and chairman of the National Research Council (NRC)—asking the NRC to coordinate development of national science education standards. The presidents of several leading science and science education associations, the U.S. secretary of education,the assistant director for education and human resources at the National Science Foundation, and the cochairs of the National Education Goals Panel all encouraged the NRC to play a leading role in the effort to develop national standards for science education in content, teaching, and assessment.Shortly thereafter, major funding for this project was provided by the Department of Education and the National Science Foundation.

To oversee the important process of standards development, the NRC established the National Committee on Science Education Standards and Assessment (NCSESA). The committee was chaired successively by Dr. James Ebert and (from November 1993) Dr. Richard Klausner. In addition, the Chair's Advisory Committee was formed, consisting of representatives from NSTA,AAAS, ACS, NSRC,the American Association of Physics Teachers, the Council of State Science Supervisors,the Earth Science Education Coalition, and the National Association of Biology Teachers. This group helped to identify and recruit staff and volunteers for all of the committees and working groups that were required.

The oversight committee (NCSESA) first met in May 1992, and the three working groups (content, teaching, and assessment) each held intense working sessions over the summer. An initial phase of standards development lasted through the fall of 1993. During that 18 months,input to the standards was solicited from large numbers of science teachers,scientists, science educators, and many others interested in science education. More than 150 public presentations were made to promote discussion about issues in science education reform and the nature and content of science education standards.

Late in 1993, work began on the production of a complete "predraft" of the science education standards. This predraft was released in May 1994 to a selected set of

focus groups for their critique and review. Each organization represented on the Chair's Advisory Committee joined by two additional organizations (NCTM and the New Standards Project) formed focus groups. In addition,the NRC convened five focus groups that were composed entirely of individuals who had not yet been involved in the project to critique the predraft. In this NRC-organized review, separate groups of experts reviewed the content, teaching, assessment, program, and system standards present in the predraft.

After the many suggestions for improving the predraft were collated and analyzed, an extensively revised standards document was prepared as a public document. This draft was released for nationwide review in December 1994. More than 40,000 copies of the draft *National Science Education Standards* were distributed to some 18,000 individuals and 250 groups. The comments of the many individuals and groups who reviewed this draft were again collated and analyzed; these were used to prepare the final *National Science Education Standards* that are presented here.

The many individuals who developed the content standards sections of the *National Science Education Standards* made independent use and interpretation of the statements of what all students should know and be able to do that are published in *Science for All Americans* and *Benchmarks for Science Literacy*. The National Research Council of the National Academy of Sciences gratefully acknowledges its indebtedness to the seminal work by the American Association for the Advancement of Science's Project 2061 and believes that use of *Benchmarks for Science Literacy* by state framework committees, school and school-district curriculum committees, and developers of instructional and assessment materials complies fully with the spirit of the content standards.

Organization

The *Standards* are organized into seven chapters. The next chapter (Chapter 2) lays out a set of overarching principles that underlie the vision of scientific literacy for all students. These principles, as well as definitions for key terms, provide the conceptual basis for the *Standards*.

Teaching and teachers are at the center of the reform in science education. The standards for science teaching are,therefore, the standards presented first. Found in Chapter 3, these standards focus on what teachers know and do. The standards for the professional development of teachers are presented next: Chapter 4 focuses on how teachers develop professional knowledge and skill. Together, the standards in Chapters 3 and 4 present a broad and deep view of science teaching that is based on the conviction that scientific inquiry is at the heart of science and science learning.

The science education assessment standards are presented in Chapter 5 as criteria for judging the quality of assessment practices. The assessment standards are also designed to be used as guides in developing assessment practices and policy. These standards apply equally to classroom-based and externally designed assessments and to formative and summative assessments.

The content standards, organized by K-4, 5-8, and 9-12 grade levels, are found in Chapter 6. These standards provide expectations for the development of student understanding and ability over the course of K-12 education. Content is defined to include inquiry; the traditional subject areas of physical, life, and earth and space sciences; connections between science and technology; science in personal and social perspectives; and the history and nature of science. The content standards are supplemented with information on developing student understanding, and they include fundamental concepts that underlie each standard.

Chapter 7 contains the program standards, which provide criteria for judging the quality of school and district science programs. The program standards focus on issues that relate to opportunities for students to learn and teachers to teach science as described in the *Standards*.

The system standards in Chapter 8 consist of criteria for judging the performance of components of the science education system beyond the school and district: the people and entities,including education professionals and the broader community that supports the schools.

Throughout the *Standards*, examples have been supplied that are based in actual practice. These examples demonstrate that the vision is attainable. Each example includes a brief description of some of its features and lists the standards that might be highlighted by the example. Many of the examples are appropriate only if students have been involved in the type of science education described in the *Standards*. For instance, the assessment exercises are appropriate if students have had the opportunity to gain the understanding and skills being assessed.

The *National Science Education Standards* are standards for all Americans: Equity is an underlying principle for the *Standards* and should pervade all aspects of science education.

Guidance for Readers

The *National Science Education Standards* are intended to serve as a responsible guide to the creation of a scientifically literate society. Because the *Standards* present a vision for scientific literacy that will require changes in the entire education system, it is expected that different individuals will read the *Standards* for different purposes. It is important that all readers read Chapter 2, *Principles and Definitions*, which sets the foundation for the vision of science education reform. The order of reading then might differ, depending on the reader's purpose. The brief guide below (Table 1.1) provides direction for locating different types of information.

TABLE 1.1. GUIDE TO USING THE *STANDARDS*

PURPOSE	
Defining scientific literacy	
	Principles and Definitions (Chapter 2) Content Standards (Chapter 6)
Providing guidance for teachers and other science educators	
	Teaching Standards (Chapter 3) Assessment Standards (Chapter 5) Professional Development Standards (Chapter 4)
Clarifying the responsibility of policy makers and the community	
	Program Standards (Chapter 7) System Standards (Chapter 8)

References for Further Reading

AAAS (American Association for the Advancement of Science).1993. Benchmarks for Science Literacy. New York: Oxford University Press.

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SCANS (Secretary's Commission on Achieving Necessary Skills). 1991. What Work Requires of Schools. Washington, DC: U.S. Government Printing Office.